

CLAIMS

1. A ternary metal colloid comprising metal nanoparticles which is composed of three different metal elements and has a three layer core/shell structure.
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2. The ternary metal colloid according to claim 1, wherein the metal element is any of platinum, palladium, silver, gold, ruthenium, rhodium, iridium, osmium, iron, cobalt, nickel, copper, and indium.
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3. The ternary metal colloid according to claim 1 or 2, wherein the metal nanoparticles are protected by a protective agent.
4. The ternary metal colloid according to claims 1 to 3, wherein the
15 protective agent is poly(N-vinyl-2-pyrrolidone), poly(sodium acrylate), polyethylene glycol, or a copolymer containing these compounds.
5. A process for producing the ternary metal colloid, said ternary metal colloid being defined in claims 1 to 4, comprising the steps of:
20 producing a first metal salt solution in which two metal ions are dispersed by dissolving two metal salts into a first solvent, and producing a first colloid solution comprising metal nanoparticles which is composed of two metal elements and has a core/shell structure by reducing the two metal ions in the first metal salt solution;
25 producing a second colloid solution as nanoparticles by dissolving one metal salt different from the two metal salts into a second solvent and by reducing the one metal ion; and
mixing the first colloid solution with the second colloid solution.

6. The process for producing the ternary metal colloid according to claim 5, wherein when the first and second colloid solutions are produced, a protective agent is added together with the metal salts.
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7. The process for producing the ternary metal colloid according to claim 6, wherein the protective agent is poly(N-vinyl-2-pyrrolidone), poly(sodium acrylate), polyethylene glycol, or a copolymer containing these compounds.
- 10 8. The process for producing the ternary metal colloid according to claims 5 to 7, wherein when the first and second colloid solutions are produced, the metal ions are reduced by the addition of a reducing agent.
9. The process for producing the ternary metal colloid according to claims 5 to 8, wherein the reducing agent is hydrogen, hydrazine, sodium borohydride (NaBH_4), alcohol, citric acid, N-methylpyrrolidone, dimethylformamide, diethylaminoboron, formaldehyde, visible rays, ultraviolet rays, gamma rays, or ultrasonic waves.
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- 20 10. A process for producing the ternary metal colloid, said ternary metal colloid being defined in claims 1 to 4, comprising the steps of:
- producing a solution in which first metal ions are dispersed in a solvent by dissolving a first metal salt into a first solvent, and producing a first colloid solution by reducing the first metal ions;
- 25 providing first metal nanoparticles in the first colloid solution with an activity as a reduction catalyst;
- producing a second metal salt solution by dissolving a second metal salt into a second solvent, and mixing the first metal nanoparticles with the

second metal salt solution and reducing second metal ions to form a binary colloid solution;

providing second metal nanoparticles in the binary colloid solution with an activity as a reduction catalyst; and

- 5 producing a third metal salt solution by dissolving a third metal salt into a third solvent, and mixing the second metal nanoparticles with the third metal salt solution and reducing third metal ions.

11. A process for producing the ternary metal colloid, said ternary metal
10 colloid being defined in claims 1 to 4, comprising the steps of:

 producing a first metal salt solution in which two metal ions are dispersed in a solvent by dissolving two metal salts into a first solvent, and producing a colloid solution comprising metal nanoparticles which is composed of two metal elements and has a core/shell structure by reducing
15 the two metal ions in the first metal salt solution;

 providing the metal nanoparticles in the first colloid solution with an activity as a reduction catalyst; and

 producing a second metal salt solution by dissolving one metal salt different from the two metal salts into a second solvent, and mixing the metal
20 nanoparticles with the second metal salt solution and reducing metal ions in the second metal salt solution.

12. The process for producing the ternary metal colloid according to claim
10 or 11, wherein in the step of providing the nanoparticles in the produced
25 colloid solution with an activity as a reduction catalyst, hydrogen is adsorbed onto the nanoparticles.

13. The process for producing the ternary metal colloid according to claim 11 or 12, wherein the metal ions in the metallic salt solution are reduced through adding a reducing agent to the solution.
- 5 14. The process for producing the ternary metal colloid according to claim 13, wherein the reducing agent is hydrogen, hydrazine, sodium borohydride (NaBH_4), alcohol, citric acid, N-methylpyrrolidone, dimethylformamide, diethylaminoboron, formaldehyde, visible rays, ultraviolet rays, gamma rays, or ultrasonic waves.
- 10 15. A process for producing the ternary metal colloid, said ternary metal colloid being defined in claims 1 to 4, comprising the steps of:
- producing a metal salt solution in which three metal ions are dispersed in a solvent by dissolving three different metal salts into a solvent; and
- 15 reducing the three metal ions.
16. The process for producing the ternary metal colloid according to claim 15, wherein the metal ions are reduced by adding a reducing agent to the solution.
- 20 17. The process for producing the ternary metal colloid according to claim 16, wherein the reducing agent is hydrogen, hydrazine, sodium borohydride (NaBH_4), alcohol, citric acid, N-methylpyrrolidone, dimethylformamide, diethylaminoboron, formaldehyde, visible rays, ultraviolet rays, gamma rays,
- 25 or ultrasonic waves.

18. The process for producing the ternary metal colloid according to claim 15 to 17, wherein when the solution is produced, a protective agent is added together with the metal salts.
- 5 19. The process for producing the ternary metal colloid according to claim 18, wherein the protective agent is poly(N-vinyl-2-pyrrolidone), poly(sodium acrylate), polyethylene glycol, or a copolymer containing these compounds.